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Comprehensive Evaluation Of Traffic Noise Pollution Based On Population Exposure

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Abstract

In this paper, the comprehensive evaluation of traffic noise pollution in Guangzhou Higher Education Mega Center based on population exposure is presented. According to the traffic flow data of 10 roads of Guangzhou Higher Education Mega Center, the traffic noise map is drawn by the noise analyzing software (*Zhong Da Sheng Tu*). By comparing the calculated results with the measured noise, it is found that the *Zhong Da Sheng Tu* software can simulate the traffic noise accurately. Further, based on the population exposure and acoustic function region, we put forward a new method to comprehensively evaluate the pollution of Guangzhou Higher Education Mega Center, which has proved to be feasible.

Keywords: traffic noise; population exposure; traffic noise simulation; Guangzhou Higher Education Mega Center

1. Introduction

As more and more universities move into Guangzhou Higher Education Mega Center, the population increases. The increasing traffic causes increasing noise, which gradually influences students', teachers' and residents' life. As a result, the living environmental quality of Guangzhou Higher Education Mega Center is restricted from improvement (Li, 2003). Vehicle radiation noise level is usually held to evaluate the road traffic noise (Hinton, Howell, et al, 2005). However, the influence of traffic noise to residents is related not only to the vehicle radiation noise level, but also to the acoustic function region and population density (Jia, 1995). In order

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to evaluate the Guangzhou Higher Education Mega Center road noise pollution level more property, the traffic noise of 10 roads (3 loops and 7 branches) was monitored, traffic volume and types, physical conditions of roadway, numbers of lanes and width of roads were recorded in this process. Based on the monitoring data of traffic flow, the traffic noise pollution was simulated by using the urban road traffic noise prediction model (Cai, Zou & Li, 2012). The survey about population distribution of Guangzhou Higher Education Mega Center was performed. Thereby, a noise pollution level based on the population exposure and acoustic function region can be proposed.

2. Traffic Noise Monitoring

2.1. Experiment

2.1.1 Experimental apparatus

Multifunctional sound level meter (AWA6228), which is calibrated by sound level meter, (AWA6221A) is employed in the experiment. The AWA6228 is complied with the 1st standard of GB/T17181-1997 and GB/T3785-1985 with a precision of 0.3dB.

2.1.2 The experimental method

According to the "Environmental quality standard for noise"(GB3096-2008), 10 roads (3 loops and 7 branches) were selected. The traffic volume, physical conditions of roadway, numbers of lanes and width for roads were measured. Surely, the traffic noise data of these roads were recorded.

The monitoring points are shown in Fig 1, which are 1.2 meters high and 7.5 meters away from the road centreline. Equivalent noise value (L_{eq}) was calculated by the average energy method in a 20 minutes monitoring time. It should be noted that the monitoring points should avoid the crossings, stations and other special points to reduce the uncertainty interferential factors.

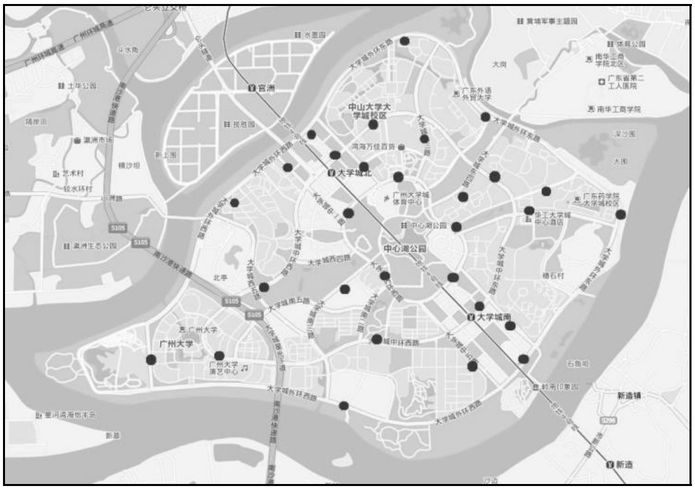

Fig. 1 Traffic noise monitoring location of Guangzhou Higher Education Mega Center

2.2. Monitoring data

Road name, monitoring location, acoustic function region, pavement material, traffic flow (volume and speed of heavy, medium, light vehicles), and L_{eq} were recorded in the experiment, and the data is shown in Table 1.

Table 1. Grouped traffic noise data on the monitoring points of Guangzhou Higher Education Mega Center

Road name	Monitoring Location	Acoustic Function Region	Pavement Material	Traffic flow heavy (veh/h)	Traffic flow medium (veh/h)	Traffic flow light (veh/h)	*Leq*(dB)
Inner Ring	Living area of SYSU	1	Asphalt	6	0	132	57.0
	Hospital	0	Asphalt	18	6	144	62.9
	Sports Centre	2	Asphalt	12	0	84	61.4
	Information building	1	Asphalt	42	12	186	61.9
	Living area of SCNU	1	Asphalt	16	30	330	69.2
Intermediate Ring	Commercial north	1	Asphalt	60	16	258	69.8
	Guangzhou University	1	Asphalt	48	6	36	62.4
	Sun Yat-Sen	1	Asphalt	36	6	120	67.8
	Commercial south	2	Asphalt	30	6	78	61.3
	GAFA	1	Asphalt	48	0	132	61.6
	SCNU	1	Asphalt	18	0	96	61.6
	GUOFS	1	Asphalt	12	0	46	53
Outer Ring	University Time	1	Asphalt	12	6	120	57.7
	Energy Center	1	Asphalt	60	18	264	62
	Chi Kan Bridge	4a	Asphalt	6	18	228	60.2
	Science Center	1	Asphalt	30	12	210	61.4
	College	1	Asphalt	12	12	66	58.8
	Front door of SYSU	1	Asphalt	12	6	414	63.8
	South pavilion village	2	Asphalt	0	12	78	58.7
	Mall	2	Asphalt	0	24	132	61.3
Branches	Concert Hall of XCOM	1	Asphalt	36	6	432	66.2
	New Internet cafes	4a	Asphalt	12	12	268	65.4
	The middle school	1	Asphalt	24	6	90	64.9
	Beigang committee	1	Asphalt	6	0	42	53.5
	Stationery store	2	Asphalt	6	0	42	52.4
	ICBC	2	Asphalt	12	6	102	57.2
	Hotel of STUC	2	Asphalt	0	4	142	59.2
	Floor of GMU	2	Asphalt	0	6	112	58.4
	Supermarket	4a	Asphalt	12	6	204	62.7

2.3. Data analysis

Most of the traffic noise values are above 60 dB in table 1. And the monitored noise value of all the roads in average is 61.16 dB, which suggests that the traffic noise pollution is serious in Guangzhou Higher Education Mega Center.

3. Population Distribution Of Higher Education Mega Center

In order to clarify the influence of noise on population exposure and get the comprehensive evaluation results of traffic noise pollution, the population distribution of Guangzhou Higher Education Mega Center is needed.

Guangzhou Higher Education Mega Center is a University Park, which includes Sun Yat-sen University, South China University of Technology and 8 other colleges. At present, the population is more than 150,000 (including students, teachers, and villagers).

The distribution of Higher Education Mega Center structures is clear and regular. And the independence of villages and teaching areas brings a lot of convenience to the survey of population distribution.

Table 2. Population statistics of Guangzhou Higher Education Mega Center

Domain Name	Quantity of people (per)	Area (m^2)	Population density (per/m^2)
Science Center	50	463499	107.88
Guangzhou University	22900	1348713	16979.15
Teaching area of GAOFA	1500	186416	8046.52
Living area of GAOFA	2500	147334	16968.29
Sun Yat-Sen University	5550	851372	6518.89
Dormitory of SYSU	10000	265633	37645.94
Accessories shop	100	162493	615.41
South pavilion village	4000	292337	13682.83
Gymnasium	100	480949	207.92
Living west area of GDGY	8750	258829	33806.06
Teaching area of GDGY	10500	496676	21140.54
Living east area of GDGY	8750	229999	38043.61
South business district	1000	752679	1328.59
Teaching area of HNLG	3000	576525	5203.59
Sui Shi village	4140	430530	9616.06
HNLG dormitory	5000	278220	17971.38
North business district	200	37254	5368.56
College of pharmacy	4500	389016	11567.65
TCM of Guangzhou University	3750	510642	7343.70
Mixed living quarters	13750	277489	49551.60
Living area of GUOFS	1500	94768	15828.05
Teaching area of GUOFS	3000	222322	13493.96
Beigang village	4700	156218	30086.24

By referencing the relevant government documents and university yearbook, the number of people in each area is counted (table 2). And the area of Higher Education Mega Center can be calculated with the help of satellite maps. Thereby, the population density distribution map of Higher Education Mega Center is drawn (Fig 2)

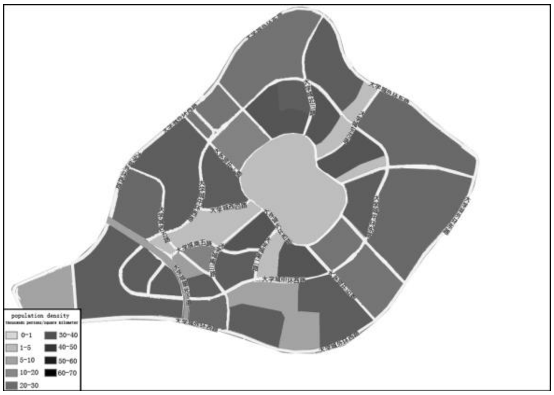

Fig.2 Population distribution of Guangzhou Higher Education Mega Center

4. Road Traffic Noise Pollution Simulations

4.1 Road traffic noise prediction model

A single vehicle without blocking around can be regarded as a point noise source in half free field. And the average noise level at a distance of 7.5 meters away from the road centerline has a relationship with speed as follows:

$$L_o = \begin{cases} 21.60 + 33.66\lg V & \text{light vehicle(asphalt pavement)} \\ 19.24 + 31.77\lg V & \text{light vehicle(cement pavement)} \\ 4.80 + 43.70\lg V & \text{medium vehicle} \\ 18.00 + 38.10\lg V & \text{heavy vehicle} \end{cases} \tag{1}$$

Where V (km/h) stands for average speed (Zhou, 1997).

Treat as a line source and take the sound attenuation into account, the equivalent sound level of the i-th type vehicles in a distance of r from the lane can be calculated as:

$$L_{eqi} = L_{oi} + 10\lg\frac{N_i}{V_i} + 10\lg(\frac{r_o}{r})^{1.5} - 16 \tag{2}$$

In this formula,

L_{oi} ——Average sound pressure level of the i-th type vehicles in the reference point

N_i ——Vehicle flow of the i-th type vehicles

V_i ——Speed (km/h) of the i-th type vehicles

r_o ——Reference distance, r_o =7.5m

r ——Distance between the receiver and driving line (m)

The equivalent sound level (Barry & Reagan, 1978) of the receiver can be defined as：

$$L_{eq} = 10\lg\sum_{i=1}^{n} 10^{0.1L_{eqi}} \tag{3}$$

4.2 Errors analysis

The volumes of heavy, medium, light vehicles flow, and the speed is got from the sample survey (the speed of heavy, medium, light vehicles is about 30, 40, 50 km/h separately). The distance from the monitoring point to the traffic line is 7.5 m. According to Eq. (1), (2) and (3), the equivalent sound theory value (L_{eq}) of monitoring point can be got.

The average error between the measured and calculated value is 1.68dB, which shows that the method of *Zhong Da Sheng Tu* can be accurately used to calculate the road traffic noise value and simulate the distribution of road traffic noise pollution of Guangzhou Higher Education Mega Center.

Table 3. Comparison of the measured noise value and the calculated noise value

Pavement	Monitoring points	Measured *Leq*	Theoretical *Leq*	Error value
Inner ring	Sun Yat-sen University	57	56.2	0.8
	Hospital	62.9	60.5	2.4
Outer ring	The university time	57.7	60.3	-2.6
	The tunnel exit	62	64	-2
Intermediate ring	The tunnel entrance	69.8	68.7	1.1
	Guangzhou University	62.4	61.7	0.7
Branches	Zhong Yi Lu	66.2	64.9	1.3
	Zhong Si Lu	65.4	64.3	1.1
	Nan San Lu	64.9	61.8	3.1

4.3 Road noise pollution map

The pollution map was rendered with the different colors filling by calculating the noise of the different position, and the map is shown in Fig 3.

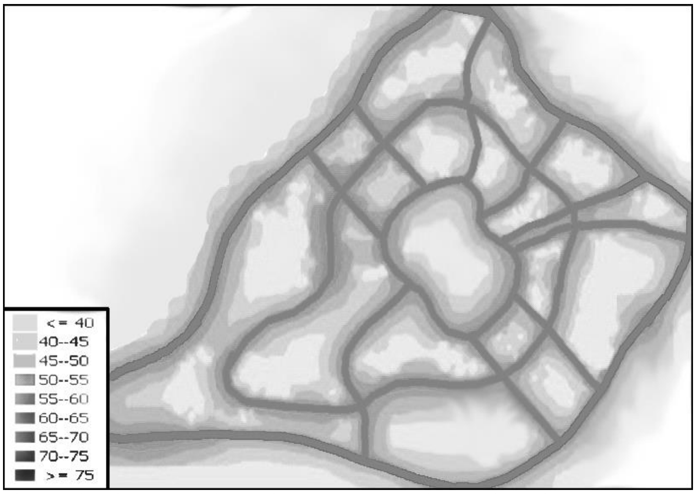

Fig.3. Road noise distribution simulation diagram of Guangzhou Higher Education Mega Center

5. Population Exposure Analysis

The relevant environmental standard of different acoustic functions region is very important for evaluations of the urban road traffic noise prediction. Table 1 shows the Chinese level recommendations and regulations (Hinton, Howell, et. al., 2005).

Table 4. Ambient noise criteria in city zone (GB 3096-2008)

Category	Area Type	Day	Night
0	Sanatorium zone, hotel, villa, etc.	50	40
1	General residential area, culture and education department etc.	55	45
e	Commercial zone, semi-industrial zone, etc.	60	50
3	General and dedicated industrial zone, industrial zone, etc.	65	55
4	Roadside	70	55

There are three types of acoustic function regions in the Higher Education Mega Center: Guangdong TCM hospital, Medical Care Center and other place where should keep quiet are contained in class 0 acoustic function region. The university teaching area, living area, research institutions and the villages are in class 1. And class 2 contains the Business South and North Zone.

Comprehensively analyzing the noise simulation data and population distribution (Fig 4), most people in the class 0 are affected by different degrees of noise pollution, and only 5% of people live in a reasonable traffic noise. In addition, it can be seen from Fig 5 that more than 10% of people in the class 1 suffer from more than 70dB. In the class 2, only 38% of people are subject to varying degrees of noise pollution (Fig 6), the crowed suffer from relatively light pollution.

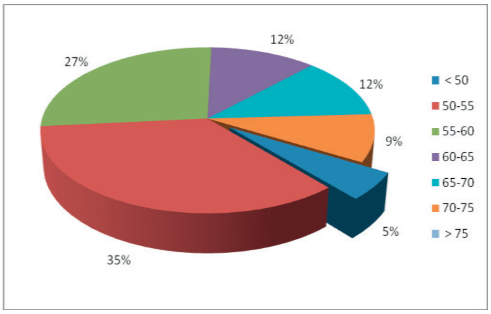

Fig. 4 Exposure population statistics in class 0

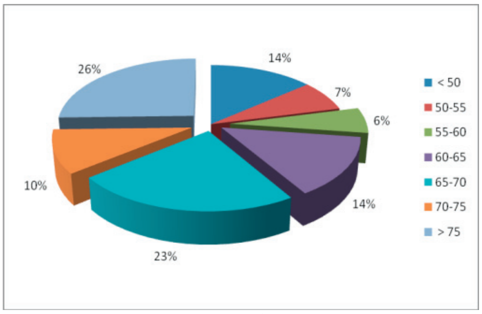

Fig. 5 Exposure population statistics in class 1

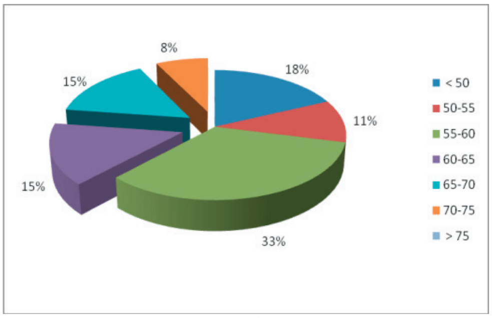

Fig. 6 Exposure population statistics in class 2

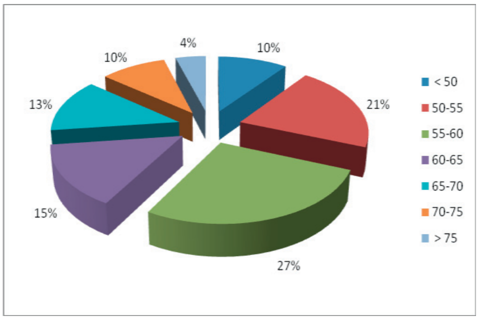

Fig. 7 Exposure population statistics regardless of acoustic function region

It can be easily seen from Fig 4, 5 and 6:

When taking the acoustic function region and population exposure into account, the pollution degrees of traffic noise is obviously different from Fig 7. This is consistent with our intuitive feelings: the more people live in excessive noise, the more serious traffic noise affection is. Likewise, for different acoustic function regions, the noise affection in the hospital is more serious than in the industrial zone.

6. Conclusions

(1) 10 different roads in Guangzhou Higher Education Mega Center were monitored to get the equivalent sound level and traffic flow information, and the traffic noise map was rendered to evaluate the traffic noise pollution level directly.

(2) Traffic noise was calculated and a noise map was drawn in this study, and the results were proved to be consistent with the measured noise.

(3) A new method was put forward to evaluate the pollution of urban road traffic noise, which has an important theoretical and practical significance.

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References

Li, J. M. (2003). Harm of Traffic Noise in Urban Roads and the Prevention & Control Methods [J]. *Foshan Urhan Planning and Surveying Research Institute*, 24(4):9-11

Hinton, J., Howell, K., et. al. (2005). BUMP-The Birmingham updated noise mapping [J]. *Acta Acustica united with Scustica*, 2005(1): 66-68

Jia, X. P. (1995). Study on assessment method of urban environmental noise [J]. *Arid Environment Monitoring*, 9 (4):236-2531

Cai, M., Zou, J. F., Li, F. (2012). Simulation and evaluation system of urban environmental noise [J]. *Acta Scientiarum Naturalium Universitatis Sunyatseni General Contents*, 51(1): 40－44.

GB 3096-2008: Noise standard in urban environment [S]. *Publishing House of China Environmental Sciences* 2008.

Zhou, Z. L. (1997). Application of NII Method in Rating Present Situation of Community Ambient Noise [J]. *Kunming University Of Science and Technology*, 22(3): 99-1031 [5]

Barry, T. M. & Reagan, J. A. (1978). FHWA high way traffic noise prediction model[R]. FHWA-RD-77-108. Washington DC: U. S. Department of Transportation.